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CONCENTRATION MEASUREMENT APPARATUS, BIOSENSOR, AND METHOD FOR MEASURING URINE COMPONENT

[Nodo Sokutei Sochi To Baiosensa Oyobi Nyochu Seibun Sokutei Hoho]

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[Claims] /2*

[Claim 1] A concentration measurement apparatus that finds the concentration of an analyte based on the biochemical reaction that progresses between the analyte in an analyte solution and a biological material, said apparatus comprising:

a biosensor that has a sensor element that converts the level of progress of the aforesaid biochemical reaction that takes place in an identifying layer that supports the aforesaid biological material into an electrical quantity;

a solution-contact detection means that detects the contacting of said analyte solution with said sensor element; and

a concentration computation means that computes the aforesaid analyte concentration based on the electrical quantity produced by the aforesaid sensor element conversion, the measurement of which quantity begins after the elapse of a given time period since said solution-contact detection means detects the contacting of the analyte solution with the sensor element.

[Claim 2] A biosensor that is used with a concentration measurement apparatus and that converts the level of progress of the biochemical reaction that takes place between an analyte in an analyte solution and a biological material into an electrical quantity, said biosensor comprising:

* Number in the margin indicates pagination in the foreign text.

a sensor element that converts the level of progress of the aforesaid biochemical reaction that takes place in an identifying layer that supports the aforesaid biological material into an electrical quantity and outputs said converted electrical quantity to the aforesaid concentration measurement apparatus, and

a solution-pouring detection sensor that detects the pouring state of the aforesaid analyte solution onto said sensor element and outputs solution-pouring detection signals to the aforesaid concentration measurement apparatus over the pouring period of said analyte solution.

[Claim 3] A urine-component measuring method that measures the concentration of a urine component using a biosensor that has a sensor element that converts the level of progress of the biochemical reaction that takes place between the urine component and a biological material into an electrical quantity, said method comprising:

a step of pouring urine onto the aforesaid sensor element, and

a step of computing the aforesaid urine component concentration based on the electrical quantity that the aforesaid sensor element converts after the completion of the pouring of urine onto the aforesaid element.

[Detailed Description of the Invention]

[0001] [Field of Industrial Application]

The present invention pertains to a concentration measurement apparatus that finds the concentration of an analyte based on the

biochemical reaction between the analyte and a biological material, to a method for measuring a urine component, and to a biosensor that can be used with this concentration measurement apparatus.

[0002] [Prior Art]

Biosensors convert the level of progress of the biochemical reaction that takes place between a biological material, such as an enzyme or a microorganism, and an analyte into an electrical quantity so as to, for example, measure the analyte in an analyte solution, such as urine or the like, and there are various known types of biosensors. There are, for example, biosensors that measure electrical potential based on changes in the ion concentration of various kinds of substances that are involved in biochemical reactions and electrode-based biosensors that measure the electrical current obtained from the electrode reaction that is brought about by the chemical substance (electrode active substance) generated or consumed by the aforesaid biochemical reactions as well as a type of biosensor that measures thermal changes that accompany a biochemical reaction with a heat measurement device and a type of biosensor that leads a biochemical reaction to chemiluminescence and measures its light emission with a photocounter.

[0003] By using a specific enzyme or microorganism as the biological material employed in these biosensors, the analyte that reacts with it can be detected selectively. For example, if glucose oxidase is used as the biological material, a biosensor that detects

glucose in urine can be obtained. A biosensor for detecting ascorbic acid in urine can be obtained by using ascorbate oxidase as the biological material.

[0004] To find the concentration of an analyte by using these biosensors, a concentration measurement apparatus that is equipped with the biosensor and a microcomputer that is comprised of a CPU, ROM, RAM, and so forth is used. When the biosensor is brought into contact with an analyte solution whose analyte concentration is unknown, this concentration measurement apparatus converts the electrical quantity (sensor output) that is input from the sensor into the concentration of the analyte; thus, the analyte concentration in the analyte solution can be found. Incidentally, to convert an electrical quantity into a concentration, an analytical curve that is stored in the ROM beforehand is generally used.

[0005] To bring an analyte solution into contact with a biosensor when measuring an analyte concentration with a biosensor and a concentration measurement apparatus, there are various methods, from which a suitable method is selected. For example, a biosensor is immersed in an analyte solution, or an analyte solution is poured onto a biosensor. In the case of measuring a urine component, the latter pouring method is employed. More specifically, a biosensor is installed inside a commode at a position that urine hits. This arrangement is preferable because, when urine is released, the urine is naturally poured over the biosensor, which then measures a urine

component, thereby eliminating the need for collecting urine in a specific container.

[0006] [Problems that the Invention Intends to Solve]

However, the concentration of an analyte in an analyte solution cannot be measured correctly in some cases. This occurs when the environment in which the biosensor is placed changes drastically before and after the contact with the solution--for example, the temperature changes suddenly, the solution-pouring pressure is applied to the biosensor, and so forth--and, as a result, noise caused by factors that are unrelated to the analyte concentration is superposed onto the sensor output. Thus, owing to the influence of noise, the measured concentration gives a higher value than the actual concentration.

[0007] The present invention was achieved to solve the aforesaid problem and intends to improve the measurement accuracy of analyte concentration.

[0008] [Means for Solving the Problems]

The means that the present invention employed to achieve the aforesaid objective is essentially a concentration measurement apparatus that finds the concentration of an analyte based on the biochemical reaction that progresses between the analyte in an analyte solution and a biological material, said apparatus comprising: a biosensor that has a sensor element that converts the level of progress of the aforesaid biochemical reaction that takes place in an

identifying layer that supports the aforesaid biological material into an electrical quantity; a solution-contact detection means that detects the contacting of said analyte solution with said sensor element; and a concentration computation means that computes the aforesaid analyte concentration based on the electrical quantity produced by the aforesaid sensor element conversion, the measurement of which quantity begins after the elapse of a given time period since said solution-contact detection means detects the contacting of the analyte solution with the sensor element. /3

[0009] The biosensor that is configured so as to be able to be used with this concentration measurement apparatus is essentially a biosensor that is used with a concentration measurement apparatus and that converts the level of progress of the biochemical reaction that takes place between an analyte in an analyte solution and a biological material into an electrical quantity, said biosensor comprising: a sensor element that converts the level of progress of the aforesaid biochemical reaction that takes place in an identifying layer that supports the aforesaid biological material into an electrical quantity and outputs said converted electrical quantity to the aforesaid concentration measurement apparatus and a solution-pouring detection sensor that detects the pouring state of the aforesaid analyte solution onto said sensor element and outputs solution-pouring detection signals to the aforesaid concentration measurement apparatus over the pouring period of said analyte solution.

[0010] The procedure employed for measuring a urine component is essentially a urine-component measuring method that measures the concentration of the urine component using a biosensor that has a sensor element that converts the level of progress of the biochemical reaction that takes place between the urine component and a biological material into an electrical quantity, said method comprising a step of pouring urine onto the aforesaid sensor element and a step of computing the aforesaid urine component concentration based on the electrical quantity that the aforesaid sensor element converts after the completion of the pouring of urine onto the aforesaid element.

[0011] [Operation]

The concentration measurement apparatus having the aforesaid configuration detects the contacting of the analyte solution with the sensor element by the solution-contact detection means and computes the analyte concentration by the concentration computation means based on the electrical quantity produced by the sensor element conversion, the measurement of which quantity begins after the elapse of a given time period since the detection of the contacting of the analyte solution with the sensor element. That is to say, the electrical quantity that the sensor element converts during a given time period since the solution-contact detection means detects the contacting of the analyte solution with the sensor element is not used for the computation of the analyte concentration by the concentration computation means. As a result, the analyte concentration can be

computed without the interference of noise caused by factors that are unrelated to the analyte concentration; thus, its accuracy is improved.

[0012] The biosensor having the aforesaid configuration outputs to the concentration measurement apparatus the converted electrical quantity from the sensor element and the solution-pouring detection signal from the solution-pouring detection sensor over the period the analyte solution is poured onto the sensor element. As a result, with a concentration measurement apparatus that employs this biosensor, it becomes possible not to use, for computing the analyte concentration, the electrical quantity converted by the biosensor while the solution-pouring detection signal is output.

[0013] Further, in measuring the concentration of a urine component by pouring urine onto the sensor element of the biosensor, the urine-component concentration is computed based on the electrical quantity that is converted by the sensor element after the completion of the pouring of urine onto the sensor element. As a result, the electrical quantity converted by the sensor element while the urine is being poured over the sensor element is not used for measuring the urine-component concentration; therefore, the influence of noise caused by factors unrelated to the urine component can be eliminated, and, consequently, the accuracy of the urine-component concentration is improved.

[0014] [Embodiment]

The following will explain a concentration measurement apparatus of one embodiment pertaining to the present invention, referring to drawings. Fig. 1 is a block diagram that illustrates the electrical structure of the concentration measurement apparatus (1) of the embodiment.

[0015] As shown in Fig. 1, the concentration measurement apparatus (1) is equipped with a biosensor (100) that has a biological material having a function of reacting biochemically with an analyte to identify said analyte and also with an apparatus main body (3).

[0016] First, the biosensor (100) will be described. This biosensor (100), as illustrated in Fig. 1, is used by connecting it in a detachable manner to a connector (5) provided for the apparatus main body (3). The biosensor (100), as shown in Fig. 2, which is a schematic perspective drawing thereof, is a planar, electrode-based biosensor and has the following structure.

[0017] As shown in Fig. 2, the biosensor (100) has a sensor element (104) and a temperature detection section (130) on a 0.7 mm-thick insulating substrate (103) (10 mm x 30 mm) that is prepared by sintering alumina. The sensor element (104) has a working electrode (105) and reference electrode (106) that are formed on this insulating substrate (103), an identifying layer (109) that supports a biological material and that is fixed onto the working electrode (105), an insulating layer (111) that insulates between the working electrode

and reference electrode (106), and terminal sections (113, 115) of the working electrode (105) and reference electrode (106). The side on which this identifying layer (109) is formed is the sensing part (117).

[0018] When an analyte solution makes contact with this sensing part (117), a biochemical reaction takes place inside the identifying layer (109) placed on the upper surface of the working electrode (105) between the supported biological material and the analyte in the analyte solution, and the current value that reflects this biochemical reaction is output to the apparatus main body (3) by means of the connector (5). The apparatus main body (3) processes this current value as the sensor output value and finds the concentration in the manner described later.

[0019] The temperature detection section (130) is for measuring the temperature of the sensing part (117) of this biosensor (100), and it is equipped with a temperature sensor (131) and lead wires (133, 135) for outputting the temperature (detection signal) detected by this element to the apparatus main body (3). The temperature detected by the temperature sensor (131) may be either the temperature of the air surrounding the sensing part (117) or the upper-surface temperature of the insulating substrate (103) on the sensing-part (117) side. This detected temperature is determined by whether the temperature-detecting surface of the temperature sensor (131) faces the surroundings or the upper surface of the substrate.

[0020] The following will explain the production process of the aforesaid biosensor (100). First, the temperature sensor (131) is provided on the upper surface of the insulating substrate (103) on the sensing-part side (117). Subsequently, electrodes for the sensor element (104) and lead wires for the temperature detection section (130) are formed. More specifically, a working electrode (105) and /4 reference electrode (106) as well as terminal sections (113, 115) and lead wires (133, 135) are formed by screen printing a platinum paste on the upper surface of the insulating substrate (103) and by drying it at 50 °C for 1 hour. In the present embodiment, a platinum paste obtained by kneading 90 % by weight of a fine platinum powder and 10 % by weight of butyl cellulose was used here. With respect to the insulating substrate (103), multiple sensor-element (104) and temperature-detection-section (130) pairs are formed on it, after which the insulating substrate is cut to the aforesaid size so that each cut piece has one sensor-element (104) and temperature-detection-section (130) pair.

[0021] Thereafter, the insulating layer (111) is formed over the working electrode (105) and reference electrode (106) as well as the lead wires (133, 135) by printing and drying an appropriate insulating agent--for example, an epoxy resin.

[0022] Next, the identifying layer (109) that supports a biological material is fixed onto the upper surface of the working electrode (105) in the manner described in the following. The

biological material supported by the identifying layer (109) is selected according to the analyte. Therefore, as a matter of convenience for explanation, the identifying layer (109) in the following explanation is assumed to be an identifying layer that supports glucose oxidase (GOD), that is to say, the biosensor (100) is assumed to be a glucose measurement sensor.

[0023] A gel-form GOD solution is formulated by kneading 94 % by weight collagen, 5 % by weight glucose oxidase (GOD), and 1 % by weight ferrocene, which is an electron acceptor (mediator). With a micropipette, this GOD solution is applied approximately 20 μm thick onto the upper surface of the working electrode (105) on the sensing-part (117) side and subsequently dried naturally at room temperature for 2 hours, thereby fixing the identifying layer (109). In this manner, a biosensor (100) having the sensor element (104) and temperature detection section (130) integrally on the insulating substrate (103) is completed.

[0024] The following will explain the apparatus main body (3). As shown in Fig. 1, the apparatus main body (3) is equipped with an electronic control unit (10) that performs concentration computation in the manner described later, a display unit (20) for displaying the converted concentration, an operation panel (30) that has a power switch and so forth, and a connector (5) to which the biosensor (100) can be connected in a detachable manner.

[0025] This electronic control unit (10) is configured as a logic operation circuit mainly from a CPU (11), ROM (12), RAM (13), and timer (14) and performs inputs and outputs to and from the exterior by means of an input/output port (16) that is connected to the aforesaid components via a common bus (15). To the input/output port (16) of the electronic control unit (10) are connected the aforesaid display unit (20), operation panel (30), and connector (5). The display unit (20) displays concentrations and so forth based on the control signals sent from the electronic control unit (10), and the biosensor (100), upon receiving the application of a measurement-use weak voltage through the connector (5), outputs the current value output by the sensor element (104) to the electronic control unit (10) and also outputs the temperature detection signal generated by the temperature sensor (131) of the temperature detection section (131) to the electronic control unit (10). Further, the operation panel (30) outputs the on/off signals of various kinds of switches to the electronic control unit (10).

[0026] The following will explain the concentration measurement control (routine) that the concentration measurement apparatus (1) of the present embodiment having the aforesaid configuration performs, referring to the flowchart shown in Fig. 3. The flowchart shown in Fig. 3 illustrates the concentration measurement routine that is executed repeatedly over the period after the power is turned on by pressing the power switch, not shown, on the operation panel (30) until the

power is turned off. As shown in Fig. 3, this routine is sequentially executed after the initial procedures that are executed only at the time of power activation, that is, clearing and so forth of the internal registers of the CPU. Following the initial procedures, it is determined from the operational state of the measurement start switch, not shown, on the operation panel (30) whether to start the measuring of the glucose concentration or not (Step 200, the "step" will be simply written as "S" in the following), and the apparatus stands by until the measurement start switch is turned on.

[0027] When it is determined at S200 that the measurement of the glucose concentration of an analyte solution--for example, urine--having an unknown concentration is to be performed, whether the urine pouring is completed or not is determined in the following manner based on the temperature detection signal output by the temperature sensor (131) (S210). When urine is poured onto the biosensor (100), the temperature sensor (131) detects the temperature of the poured urine and outputs the temperature detection signal that reflects the urine temperature to the electronic control unit (10). Since the temperature of the urine discharged from the human body is approximately the same as the body temperature (approximately 36.5 degrees), the temperature sensor (131) detects a temperature close to the body temperature immediately after the start of urine pouring and over the urine-pouring period. Then, when the urine pouring is completed, the temperature of the urine adhering to the temperature

sensor (131) as well as to the sensing part (117) of the sensor element (104) decreases; therefore, the temperature detection signal that is output from the temperature sensor (131) to the electronic control unit (10) also becomes a signal that corresponds to the lower temperature. In the ROM (12) is stored in advance the temperature that should be detected as the urine temperature during the urine-pouring period by the temperature sensor (131). Therefore, the electronic control unit (10) to which the temperature detection signal is input determines whether the urine pouring onto the biosensor (100) is completed or not from this stored temperature and from changes in the temperature (temperature detection signal) actually detected by the temperature sensor (131).

[0028] Incidentally, the pouring of urine can be carried out in any mode. For example, urine may be suctioned into a dropper or the like and poured onto the biosensor (100), or urine discharged from the human body may be directly poured onto the biosensor (100). In the case of pouring urine in the latter mode, it is desirable to employ the following configuration. As shown in Fig. 4, the biosensor (100) is installed inside a commode (150) at the leading end of a retractable arm (151) through the connector (5), and, when the measurement start switch is turned on at the aforesaid S200, the arm (151) is driven by a driving device, not shown, to move the biosensor (100) to the position inside the commode (150) at which position the biosensor can be doused with urine. In this case, the driving device

for the arm (151) is activated by a control signal from the electronic control unit (10) and drives the arm (151).

[0029] When it is determined at S210 that the pouring of urine /5 onto the biosensor (100) is completed, the electronic control unit (10) starts reading the sensor output (current value) of the sensor element (104) from that point on (S220) and computes the glucose concentration in the urine from the read sensor output and an analytical curve (Kcal) (S230) like the one shown in Fig. 5. This analytical curve (Kcal) is stored in advance in the ROM (12) as analytical-curve-use mapping data that correlates sensor outputs with glucose concentrations.

[0030] Thereafter, the electronic control unit (10) outputs the control signal corresponding to the value of the computed glucose concentration to the display unit (20), thereby displaying the glucose concentration value (S260), and the process of the present routine is ended.

[0031] The concentration measurement apparatus (1) of the present embodiment having this configuration was compared in the following manner with a conventional concentration measurement apparatus that measured the glucose concentration in urine based on the sensor output from immediately after the start of the pouring of urine. The supported GOD quantity, thickness of the identifying layer, and so forth in both concentration measurement apparatuses were identical. A glucose reagent whose glucose concentration was adjusted to a given

value--for example, to 100 mg/dl--and whose temperature was adjusted to a temperature close to urine to the body temperature [sic] was poured onto the biosensor of each of the aforesaid concentration measurement apparatuses with a pouring device, such as a dropper, injection syringe, or the like, thereby measuring the glucose concentration. As a result, with the concentration measurement apparatus (1) of the present embodiment, 99.5 mg/dl was obtained as the concentration of the aforesaid glucose reagent based on a sensor output current value of 21 x 10^{-3} mA, whereas the aforesaid conventional concentration measurement apparatus yielded 107 mg/dl based on a sensor output current value of 22.5 x 10^{-3} mA. With glucose reagents whose glucose concentrations were adjusted to different values, the concentration measurement apparatus (1) of the embodiment could find the adjusted glucose concentrations, but the conventional concentration measurement apparatus only obtained a concentration that was higher than the adjusted glucose concentration from every solution.

[0032] As explained in the foregoing, because the concentration measurement apparatus (1) of the present embodiment measures the glucose concentration from the sensor output detected by the sensor element (104) after the completion of the pouring of an analyte solution, such as urine or the like, the apparatus can eliminate the influence of noise caused by the pouring of urine during the pouring period and, thus, can find the glucose concentration accurately. That

is to say, the measurement accuracy of glucose concentration can be improved.

[0033] Furthermore, in the concentration measurement apparatus (1) of the present embodiment, the identifying layer (109) supports ferrocene as the electron acceptor (mediator) in addition to GOD; therefore, even if the analyte solution is urine, which contains little dissolved oxygen, its glucose concentration can be determined accurately.

[0034] The following will explain a modified example that does not use the temperature sensor (131) in measuring the glucose concentration from the sensor output obtained after the completion of the pouring of an analyte solution. In this modified example, in place of the aforesaid biosensor (100) is used a biosensor (100A), not illustrated, that is configured from the sensor element (104) alone. Further, in place of the concentration measurement routine illustrated in the flowchart in Fig. 3, the concentration measurement routine shown in Fig. 6 is employed. The following will explain the concentration measurement apparatus (1) of the modified example, referring to this flowchart. The same procedures as those in the flowchart in Fig. 3 will be indicated by the same step numbers, and their explanation will be simplified.

[0035] First, it is determined whether to start the measuring of glucose concentration or not (S200), and the apparatus stands by until the measurement start switch is turned on.

[0036] When it is determined at S200 to execute the measurement of glucose concentration in urine, it is determined whether a given sensor initial output value is output from the sensor element (104) or not (S202), and the apparatus stands by until this sensor initial output value is input. This sensor initial output value is set as a value that is always output from the sensor element immediately after the start of the pouring of urine onto the biosensor (100A) and is stored in the ROM (12) in advance. Then, when the sensor initial output value is obtained from the sensor element (104) as the sensor output, it is determined that the pouring of urine has been started, upon which point the timer (14) is initialized, and, at the same time, the reading of the sensor output from the sensor element (104) is suspended (S204).

[0037] Next, it is determined (S206) from the time kept by the timer if a given time period has elapsed or not since the sensor initial value output was input, and the apparatus stands by until a given time period elapses. This given time period is set to the time that is normally required for urination--for example, from 20 to 30 seconds--and stored in the ROM (12) in advance. Here, when the given time period elapses after the input of the sensor initial value output, it can be determined that the pouring of urine onto the biosensor (100A) is completed.

[0038] When, by means of timekeeping of the elapsed time period, it is determined that the pouring of urine has been completed, the

timer is reset (S208), and the electronic control unit starts reading the sensor output (current value) of the sensor element (104) from that point on (S220) and computes the glucose concentration in the urine from the read sensor output and the analytical curve (Kcal) (S230). Thereafter, the glucose concentration value is displayed (S260), and the process of the present routine is finished.

[0039] Also with the concentration measurement apparatus (1) of the modified example having this configuration, the completion of the pouring of an analyte solution, such as urine or the like, is determined from the passage of a given time period since the sensor initial output value is obtained, and the glucose concentration is measured based on the sensor output that is detected by the sensor element (104) after the completion of the solution pouring. As a result, similarly with the embodiment that employs the temperature detection section (130), the present example can find glucose concentration accurately and can improve the measurement accuracy of glucose concentration.

[0040] The present invention is not limited to the aforesaid working examples and can be implemented in various modes within the scope of the invention, and the following modifications are possible. For example, in place of glucose oxidase in the biosensor for glucose measurement, an enzyme, such as pionose [as transliterated] oxidase, /6
mutarotase, or the like, or a microorganism, such as Pseudomonas fluorescens or the like, may be used. Furthermore, the analyte is not

limited to the aforesaid glucose, and it may be ascorbic acid, uric acid, urea, bilirubin, or the like. It goes without saying that, according to these analytes, appropriate biological materials are selected.

[0041] In place of the temperature sensor (131) in the temperature detection section (130), a pressure sensor or vibration sensor may be provided integrally with the sensor element (104). In the case of using a pressure sensor or vibration sensor, a reference level for the pressure or vibration that naturally acts on these sensors during the urine-pouring period is stored in the ROM (12) in advance, and a period in which a sensor output that is higher than this reference level is obtained from the pressure sensor or vibration sensor is considered to be the urine-pouring period.

[0042] Furthermore, the aforesaid embodiments are configured to read the sensor outputs for the concentration measurement after the completion of the urine pouring, but it is also possible to configure the apparatus to read all the sensor outputs from immediately after the pouring starts to the completion of the measurement. In this case, each sensor output and elapsed time are correlated with each other and stored sequentially in a given address of the RAM (13), and the concentration of the analyte is computed only from the sensor output of each address that corresponds to the time that elapses from the point of time at which the completion of the urine pouring is determined.

[0043] [Effects of the Invention]

As explained in the foregoing, the concentration measurement apparatus of the present invention does not use the electrical quantity obtained from the sensor element during a given time period that elapses from the contacting of the analyte solution with the sensor element, and it computes the concentration based on the electrical quantity that it obtains after the passage of a given time period. As a result, the concentration measurement apparatus of the present invention can eliminate the interference of noise caused by factors that are unrelated to the analyte concentration and finds the analyte concentration accurately; thus, the improvement of its measurement accuracy can be achieved. Especially when the analyte is a component contained in urine, the concentration measurement apparatus and measuring method of the present invention make it possible to accurately measure the urine-component concentration in urine discharged directly from the human body at the time of urination.

[Brief Explanation of the Drawing]

[Fig. 1] A block diagram that illustrates the electrical structure of the concentration measurement apparatus (1) of one embodiment.

[Fig. 2] A schematic perspective drawing of the biosensor (100) of the embodiment.

[Fig. 3] A flowchart that illustrates the concentration measurement routine that the concentration measurement apparatus (1) performs.

[Fig. 4] An explanatory drawing for explaining the use condition of the biosensor (100).

[Fig. 5] A graph that indicates an analytical curve (Kcal) that correlates glucose concentrations and sensor output current values.

[Fig. 6] A flowchart that illustrates the concentration measurement routine that the concentration measurement apparatus (1) of the modified example performs.

[Explanation of Reference Numerals]

1 Concentration measurement apparatus

3 Apparatus main body

10 Electronic control unit

20 Display unit

30 Operation panel

100 Biosensor

104 Sensor element

105 Working electrode

106 Reference electrode

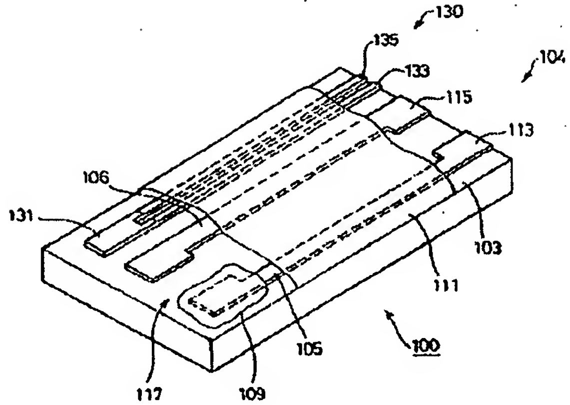
109 Identifying layer

117 Sensing part

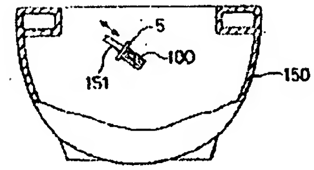
130 Temperature detection section

131 Temperature sensor

[FIG. 2]

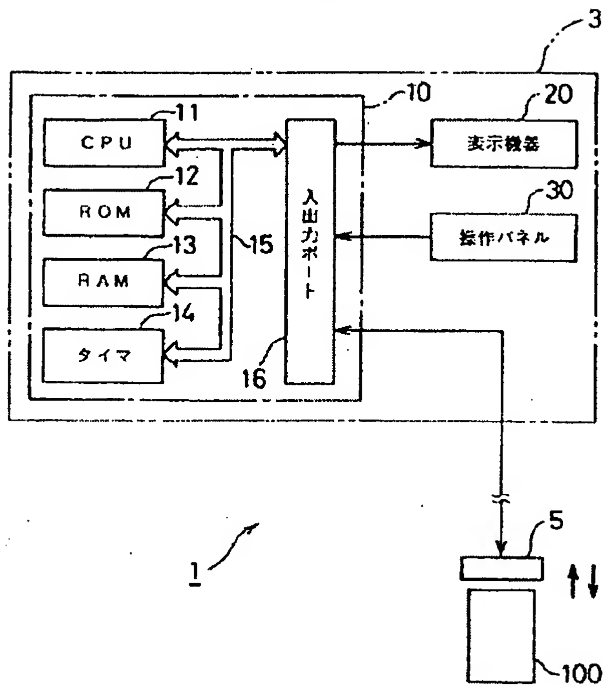


[FIG. 4]



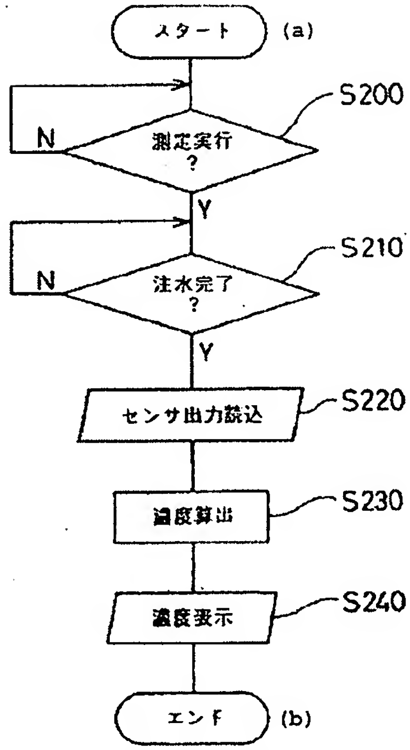
/7

[FIG. 1]



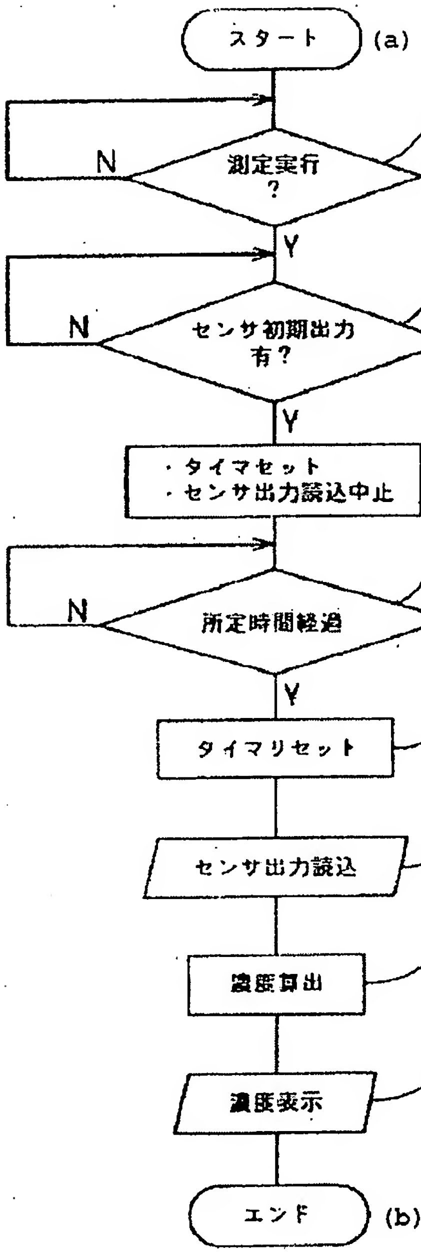
Key: 14) timer; 16) input/output port; 20) display unit; 30) operation panel.

[FIG. 3]



Key: a) start; b) end; S200) execute measurement?; S210) the solution-pouring completed?; S220) read sensor output; S230) compute the concentration; S240) display the concentration.

[FIG. 6]



Key: a) start; b) end; S200) execute measurement?; S202) sensor initial output received?; S204) set the timer, suspend reading sensor output; S206) passage of a given time period; S208) reset the timer; S220) read sensor output; S230) compute the concentration; S240) display the concentration.

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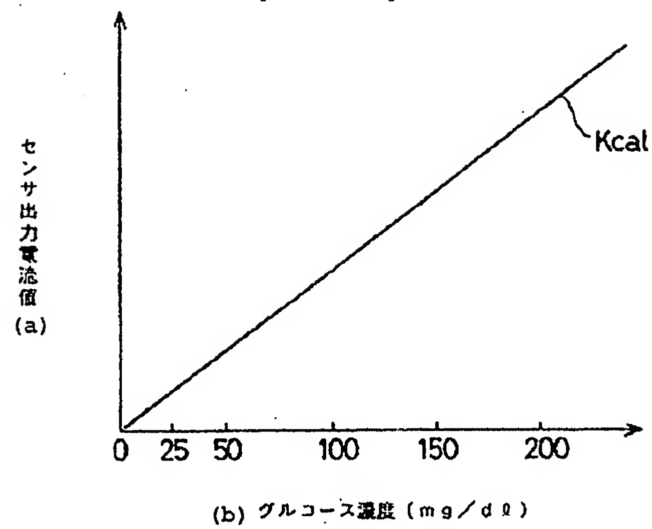
[FIG. 5]



Key: a) sensor output current value; b) glucose concentration.